REQUIREMENTS AND USE OF INDIRECT METHODS FOR ESTIMATING THE HYDRAULIC FUNCTIONS OF UNSATURATED SOILS

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The solution of field-scale flow and transport problems requires accurate estimates of the unsaturated soil hydraulic parameters. Direct field and laboratory measurement of the hydraulic functions is time consuming and expensive. By comparison, indirect theoretical methods that predict the soil hydraulic functions from more easily measured soil texture data, organic matter content, bulk density and other data are more convenient. The accuracy and comparability of the predicted unsaturated soil hydraulic functions depends on the method used for measuring soil texture and related data. In this paper we discuss the need for developing an international database of measured soil hydraulic data as a function of soil type and the experimental methodology. The database should contain such information as the soil water retention function, the unsaturated hydraulic conductivity function, the particle-size distribution, bulk density, organic matter content, and related data. The hydraulic properties in the database must be obtained with internationally standardized procedures, equipment, and methods of analysis. Estimation of the unsaturated soil hydraulic parameters demands standardized software tools linked to a representative soil database of manageable size. Modeling of subsurface flow and transport often requires the transformation from point values to areal values of the hydraulic parameters. This may be done by including additional software for estimating the unsaturated soil hydraulic parameters in time and space.

INTRODUCTION

Since many reliable numerical models for simulating soil water flow are now available [*Campbell*, 1985; *Richter and Anlauf*, 1988], the accuracy of site-specific simulations increasingly hinges on the reliability of model parameters. Misleading results are easily obtained unless careful attention is given to the selection of the unsaturated soil hydraulic properties [*Scotter et al.*, 1988]. Model applications may include (1) detailed investigations of an experimental plot, (2) assessments of hydrological or agricultural properties of watersheds or other large areas, and (3) assessments of the hydraulic or mechanical properties of soil units, regardless of their location. For these applications, and for future use by researchers, it is beneficial if soil physical data, measured for a wide variety of soils, are easily accessible. This paper will discuss some of the problems associated with the development of a soil database, and the use of indirect methods to estimate parameters of soil hydraulic functions to be incorporated in such a database.

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DEVELOPMENT OF A DATABASE OF SOIL PHYSICAL PROPERTIES

Results of soil physical measurements are scattered throughout the soil physics and hydrology literature. Experiments are generally carried out to meet specific objectives, and the results of such individual studies are therefore often too incomplete to be useful for others. To alleviate this problem, we recommend the development of a database of measured soil physical properties. Retrieving information from such a database is obviously far less time-consuming than collecting data from original literature sources. Also, additional information can readily be incorporated in the database to make the measurements more useful for application by others. Hence, the existence of such a database could potentially save a considerable amount of time and effort.

One of the main problems associated with the development of a soil database is the great diversity of experimental methods used in soil physics, hydrology, and related disciplines. Results obtained with different measurement methods are often not comparable. This point is illustrated in Figure 1, which compares measured particle-size distributions obtained with the sedimentation method (Bouyoucos hydrometer) to those obtained with an optical particle-size analyzer. The two curves are quite different, particularly for grain sizes between 0.006 and 0.06 mm. Differences such as those shown in Figure 1 may arise because of different measurement principles and/or different instrumental techniques [e.g., *Nitsche et al.*, 1992]. Hence, methods for indirectly estimating soil hydraulic properties from soil textural data [e.g. *Rawls and Brakensiek,* 1985] must account for differences in the experimental methodology. Soil texture data used to formulate the predictive regression equations for the water retention curve, may have been obtained with radically different methods than the textural data of the soil for which the water retention needs to be predicted.

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Fig. 1. Cumulative grain-size distribution for a loamy sand obtained with optical particle-size analysis and the sedimentation method.